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Barriers to Routine UAV Operation in the National Aerospace System

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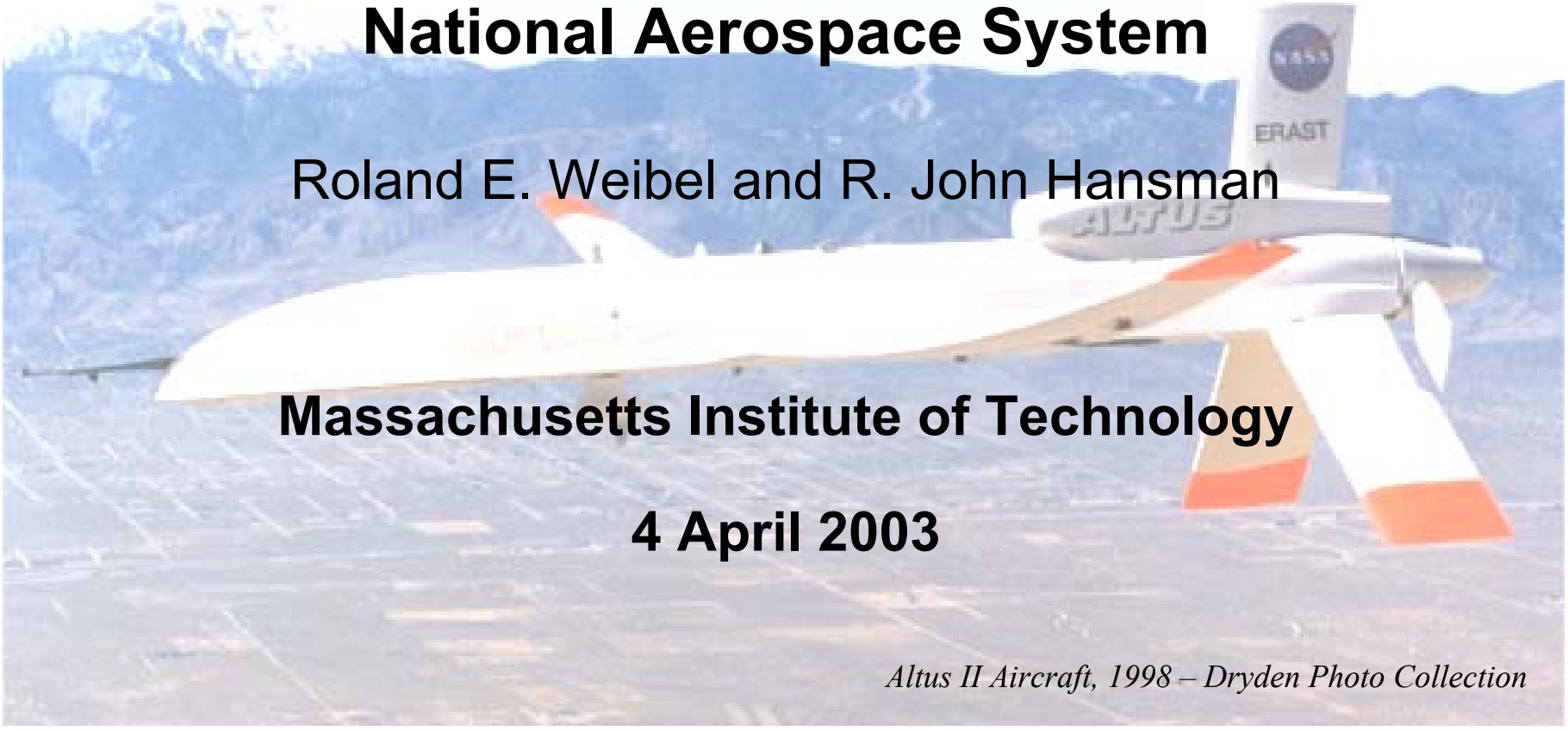


Altus II Aircraft, 1998 – Dryden Photo Collection

Possible UAV Applications - Motivation

- **Remote Sensing**
  - Meteorology
  - Scientific Research
  - Aerial Photography/ Mapping
  - Pipeline Spotting
  - Disaster Monitoring
- **Aerial Surveillance**
  - Border Patrol
  - Homeland Security/ Law Enforcement
  - Traffic Monitoring
- **Communications Relay**
- **Search and Rescue**

➔ ***Routine Access to NAS Needed***

Approach

1. **Identify and Understand Potential Barriers to Routine UAV Operation in NAS**

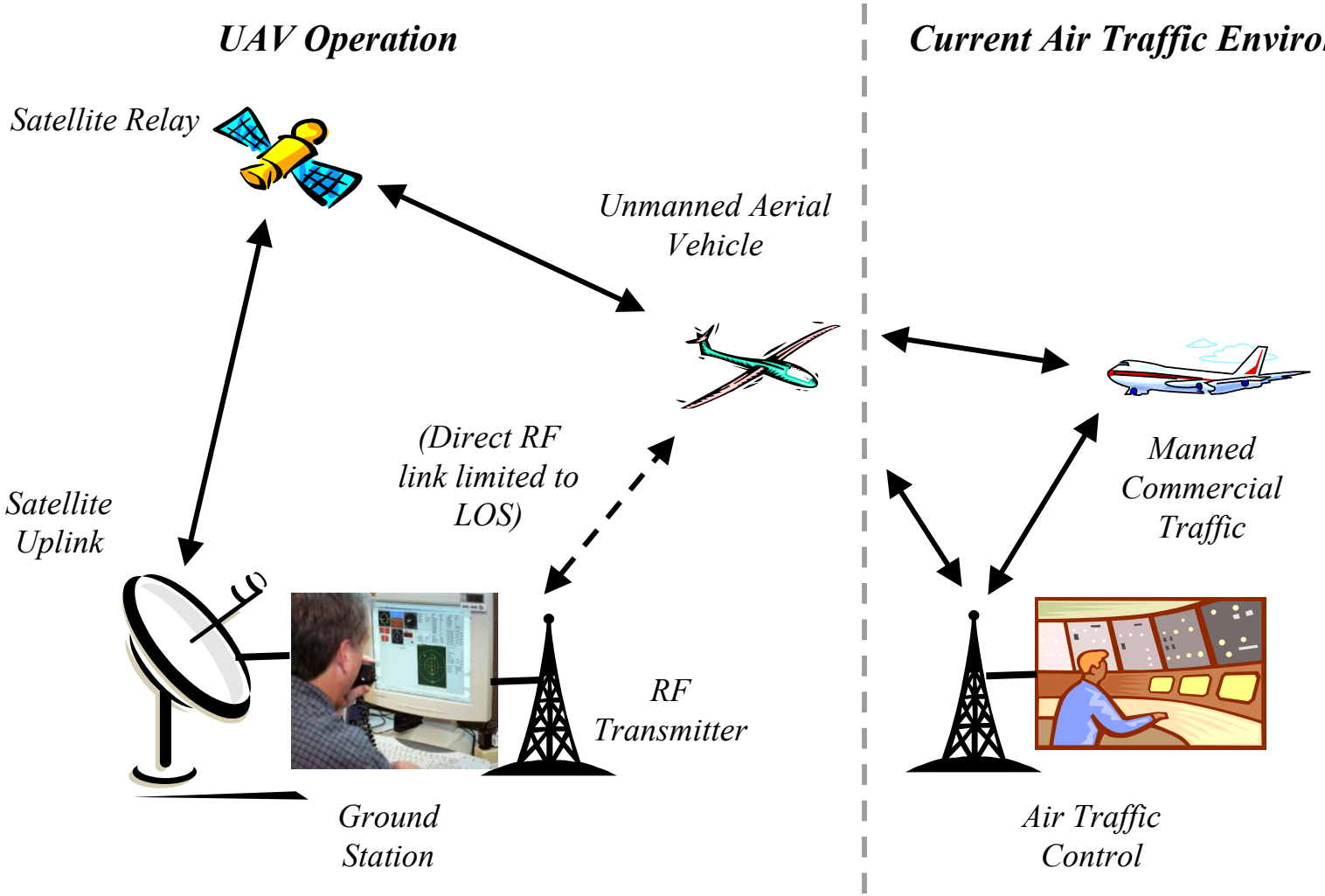
2. **Examine Potential Technologies or Processes to Overcome the Barriers**

3. **Conduct a Detailed Systems Analysis of the Human-Machine System – Using Semi-Structured Decision Framework**
   - Determine Optimal Human-Automation Allocation
   - Determine Where Human Adds Value to System
   - Integrate Required Technologies or Processes into System

Barriers to Routine Access

- Federal Aviation Regulations Did Not Anticipate Presence of Unmanned Aircraft
- Present Infrastructure Not Configured For Unmanned Operations
- UAV System Failures Must Meet Equivalent Level of Safety to Manned Operations
- Public Must be Protected from Rogue Aircraft Use

UAV Operational Environment



Regulations Did Not Anticipate Remote Aircraft Operation

- **Part 61 – Certification of Pilots, Flight Instructors, and Ground Instructors**
  - Pilot certification requires knowledge of aerodynamics, aircraft systems, and regulations
  - Guarantees competent operator in command of vehicle
- **Part 23,25 – Airworthiness Standards**
  - Guarantees airplane is airworthy and controllable by the pilot
  - Standards scale by number of passengers aboard aircraft
- **Part 91 – General Operating and Flight Rules**
  - Requires pilot vigilance to “see and avoid” other aircraft in good weather conditions
  - Positive separation provided by air traffic control in poor weather or different airspace

➔ ***Pilot in Command Responsible for Safety of Flight***

Regulations Did Not Anticipate Remote Aircraft Operation

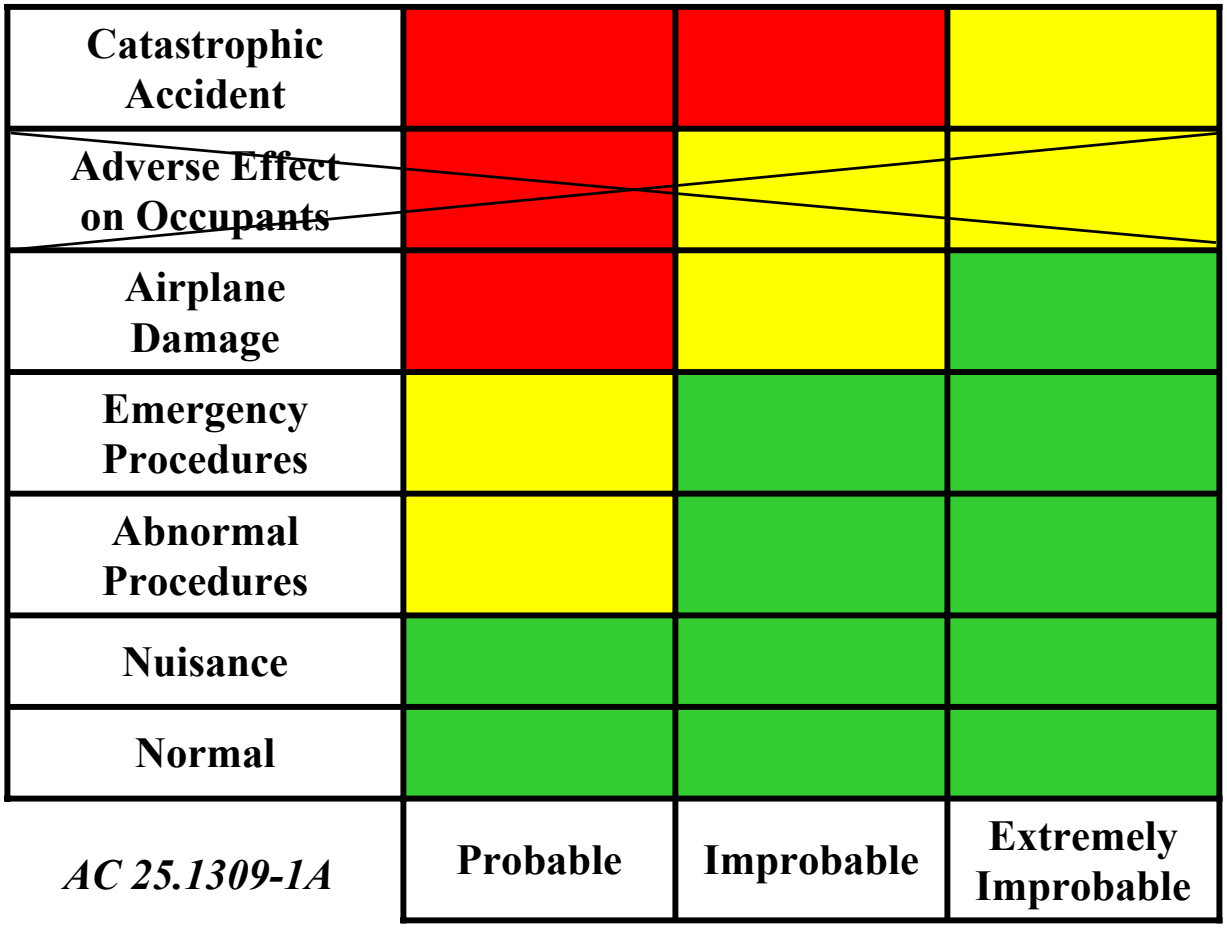
Current Process: Certificate of Approval

- **Contained in FAA Order 7610.4 – Special Military Operations**
- **60 Day Advance Notice Required**
- **Detailed Characteristics of Operation**
  - Coordination, Communication, Operational Procedures
  - Method of Pilotage, Avoidance of Other Aircraft
  - Lost Link, Mission Abort Procedures
- **Guarantee of Equivalent Level of Safety**

Safety Elements

- **Vehicle Airworthiness**
- **Training and Operating Procedures**
- **Maintenance**
- **Culture**
  - Quality Management Processes
  - Incident Reporting
  - Accident Investigation
- **Liability**

Equivalent Level of Safety – Probability vs. Consequences



➔*Consequences of Failure Change for Unmanned Operation*

Descriptive Probabilities

Probability (per unit of exposure)	FAR	JAR
1		Frequent
10E-3	Probable	
		Reasonably Probable
10E-5		
		Remote
10E-7	Improbable	
		Extremely Remote
10E-9		
	Extremely Improbable	Extremely Improbable

Probabilities and Consequences

- **Adverse Effect on Occupants not Applicable to UAV Operations**
- **Catastrophic Accident Worst Consequence of Failure**
- **"Catastrophic Events" Change Without People Onboard Aircraft**
  - Loss of Aircraft No Longer Automatically Catastrophic
  - Example Possibilities
    - Collision of UAV with Manned Aircraft
    - Crash of Aircraft Over Densely Populated Area

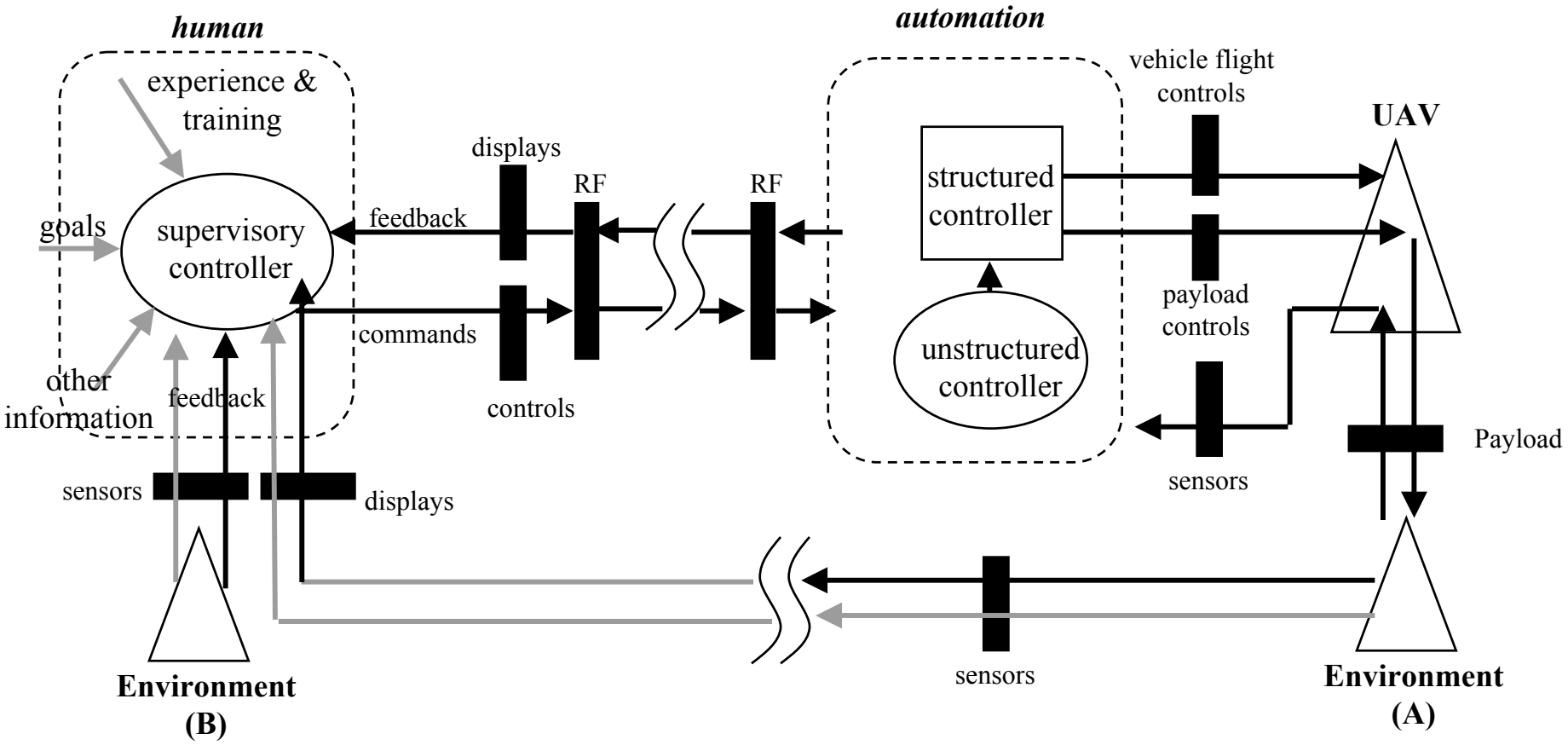
➔Equivalent Level of Safety Must be Examined for Unmanned Operations

Public Must Be Protected From Rogue Aircraft Use

- **Commercial Aircraft**
  - Passenger Screening at Airports
  - Cockpit Security
  - Onboard Law Enforcement (Air Marshals)
  - Difficulty of Operation
- **Civil Aircraft/ Ultralights**
  - Security of Public / Private Property
    - (Locked Aircraft, Secure Airport)
  - Operational Restrictions
  - Non-Suicidal Pilots
- **Unmanned Aerial Vehicles**
  - Threat Level Depends on Size and Capability
  - Security Measures must Reflect Threat Level

Reduced Threat, Less Security

Semi-Structured Process – UAV Supervisory Control



Notation from Kaliardos, 1999

➔*Details of Automation Block Unknown*

Next Steps

- Examine Procedures or Technologies Needed to Interface with Current Air Traffic Management System
- Discriminate Different Types of UAV Operation for Varied Certification Levels
- Assess Possible Failure Modes of UAV Operations and Consequences
- Determine Role of Operator in Liability for Operations and Level of Control Over Vehicle